Chronic Obstructive Pulmonary Emphysema

Is Exercise Beneficial?

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■ *Following a six-week program of training in a series of exercises, a significant number of patients with chronic obstructive pulmonary emphysema showed decided improvement in functional activity. Subjective improvement also was noted and kept the patient motivation high.*

Preliminary observations indicated that the improvement could be maintained long after the end of the training period.

CHRONIC OBSTRUCTIVE PULMONARY emphysema (COPE) is an increasingly important medical problem. It is estimated that in the last 10 years the number of patients with this disease has quadrupled.[1] U.S. Public Health Service surveys in 1960 estimated more than one million persons had emphysema.[8,9] Deaths from the disease in 1963 totaled 17,595, an increase of 600 per cent from 1953.[1]

The treatment is controversial and various therapeutic regimens have been tried. Many investigators consider the stress imposed by exercise to be deleterious for patients with COPE. For this reason, limitation of physical activity is recommended. Noehren[13] listed 23 therapeutic measures but did not mention graded exercises. Yet clinical observations, such as Barach,[3,4] Pierce,[14] Lyons[11] and Miller,[12] indicate that patients with COPE benefit from physical exercise.

This presentation is concerned with evaluating the efficiency of a specific physical treatment program combined with the usual medical treatment.

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Material and Methods

Forty-three male patients with chronic obstructive pulmonary emphysema, all of them in hospital, were selected for a program of graded exercise training. Pulmonary function studies, blood gas analysis and various functional activities and patients' attitude (Table 1) were measured at the beginning and at the end of a six-week period. Three dropouts occurred, two due to severe illness and one to emergency operation. The patients were treated five days weekly in groups of four to five, in air-conditioned rooms. None had previously followed a program of regular exercises. The grade of dyspnea and tests of ventilatory functions of the remaining 40 patients at the beginning of the training and at the end of six weeks are shown on Table 2.

The combined exercise program (Table 3) consisted of breathing exercise, relaxation exercise, postural exercise and general conditioning exercise.

Breathing Exercises. Breathing exercises consisted of training in diaphragmatic breathing—inhalation through nose and exhalation through pursed lips, with exhalation controlled to take twice as long as inhalation. A metronome was used for training and indoctrination. These exercises

were done in sitting, standing and supine positions. In the supine position, with the head lowered 15°, the patient placed one hand on the thoracic cage and the other on the abdomen to gain tactile sensation of diaphragmatic movements. Later, in the supine position, weight (sandbags 2 to 30 pounds, as tolerated) was placed on the abdomen to accentuate the rise on inhalation and the fall on exhalation. Exercises used by the British Asthma Research Council were followed in general.[2]

In the afternoon blow bottle exercises were used in sitting and standing positions for a total of 20 minutes.

Physical Relaxation Exercises. Physical relaxation exercises were practiced in sitting, standing and recumbent positions. The patients were made aware of their contracted and relaxed muscles in sitting and recumbent states.

Postural Exercises. The postural exercises were performed once daily for 10 minutes in standing and sitting positions. (Before each training session, the therapist stressed posture.)

Progressive Resistive Exercises. Progressive resistive exercises consisted of upper extremity, lower extremity and trunk exercises in the gymnasium twice daily. Wall pulleys, treadmills, rowing machines and exercise tables, shoulder wheels and weights were mingled for a change of program. Progressive ambulation and stair climbing were practiced daily.

Before the program of exercises was begun, medical history, physical examination and laboratory tests (including complete blood cell count, urinalysis, x-ray film of chest and electrocardiogram) were completed. After examination, the patients were graded in accord with the respiratory system classification of the Committee of Rating of Mental and Physical Impairment[6] (with slight modifications). Table 4 shows the grades of ventilatory function and dyspnea. (The grade of dyspnea does not correspond at all times with the grade of ventilatory functions shown in Table 2.)

None of the patients was acutely ill during the

TABLE 1.—*Measurements of Ventilatory Function and Activities*

Test of Ventilatory Function	Forced expiration volume, liters (FEV)
	Maximum voluntary ventilation L/Min. (MVV)
Arterial Blood Studies	Blood pH, units
	O_2 saturation per cent
	O_2 tension, mm mercury
	CO_2 tension, mm mercury
Functional Activities	
Muscle Strength	
Relaxing Ability	Walking on level—distance and time
	Stair climbing—number of flights and time
	Exerow activity tolerated, time
	Walking on Treadmill 15° incline, distance and time
	Hand grip measurements, pounds
	General strength
	Relaxing ability
Breathing Exercises	Number of blows required to transfer 1 liter of water
	Longest single blowing time
	Chest expansion changes:
	a. Nipple line
	b. Rib angle
	c. Navel line
Occupational Therapy	
Activity	Activity tolerance
	Attendance
	Motivation

TABLE 2.—*Grade of Dyspnea (Functional Activity)*

Grade	*Initial*	*Six Weeks*
I	0	4
II	3	15
III	18	12
IV	12	9
V	7	0

No grade change in 10 patients. One grade up in 26 patients. Two grade up in four patients.

Test of Ventilatory Function—Forced Expiration Volume (FEV) *and Maximal Voluntary Ventilation* (MVV)

Grade	*Initial*	*Six Weeks*
I	0	3
II	7	4
III	7	15
IV	19	14
V	7	4

No grade change in 20 patients. One grade up in 17 patients. One grade down in three patients.

TABLE 3.—*Exercise Schedule*

9:15-10:00	Postural drainage, breathing, relaxation and conditioning exercises
10:00-11:00	Rest, recreation, room activities
11:00-11:30	Relaxation, breathing, posture exercises
11:30-12:00	General conditioning exercises in the gymnasium with treadmill, pulley, rowing machine, exercise table, etc
12:00- 2:00	Lunch, rest
2:00- 2:30	Breathing, relaxation, ambulation exercises
2:30- 3:00	Breathing (blow bottles) ambulation, stair climbing exercises
3:00- 4:00	Occupational therapy program (plastic —bench work, floor looms)
4:00- 5:00	Rest, supper

TABLE 4.—*Data on Ventilatory Function and Functional Activity Related to Grade*

Test of Ventilatory Function	*Grade*	*Dyspnea Functional Activity*
Not less than 85 per cent of the predicted normal	I	Unrestricted
70-85 per cent of the predicted normal	II	Can do moderate activity
55-70 per cent of the predicted normal	III	Can do light work, not involving hurrying, climbing, heavy lifting
55-35 per cent of the predicted normal	IV	Present on level walking of 100 yards, or after few minutes
Less than 35 per cent of the predicted normal	V	Present on slight exertion, dressing, talking, even at rest

training and observation period. The medical treatment (consisting mainly of bronchodilator therapy, intermittent positive pressure breathing) was continued during the observation period. Avoidance of respiratory irritants (smoking) was stressed.

Thirty-three patients had a history of heavy cigarette smoking (more than one package daily). Seven said they did not smoke. Sixteen said they had a heavy intake of alcohol, 19 that they drank "socially" and five denied drinking.

Previous pulmonary disease was discovered in 36 patients (tuberculosis, bronchitis, asthma). Eight patients had previous histories and findings of right heart failure, and 20 had gastrointestinal complaints and findings.

Four patients were between 35 and 44 years of age, another four between 45 and 54, seven 55 to 64, twenty-two 65 to 74 and three over 75. The youngest patient was 39 and the oldest 78. There were 36 Caucasians, three Negroes and one Oriental.

All patients received and used the Gordon-Barach Belt for abdominal support.

After the period in hospital the patients were urged to continue their training program of the exercises they had learned, and blow bottles were issued to patients for home use.

Results

Of the two variables in ventilatory function that were tested, forced expiration volume (FEV) and maximal voluntary ventilation (MVV), the FEV showed an increase in the mean value, significant at better than 0.01 probability level. The mean value changes in MVV were statistically not significant. However, the oxygen tension measured showed a differential at the 0.05 probability level. Blood pH, oxygen saturation and carbon dioxide tension did not show significant changes. Table 5 shows the six variables measured, the mean values before and after training and the differences between the values.

Functional Activities. Greatest improvement was registered in the tests of functional activities. All the activities, except speed of stair climbing, showed improvement at the probability of 0.01 level. All of the tests for increased endurance were highly significant with Student's "T" test values of 3 to 7. Speed of stair climbing would appear to be a measure of other factors besides endurance.

Breathing Exercises. Significant improvement was noted in both the number of blows required (Table 1) and in the longest single sustained blow, as was to be expected with training. However, the

TABLE 5.—*Test of Ventilatory Function and Arterial Gas Studies*

*Variables** First	Second	*Mean of First Variable*	*Mean of Second Variable*	*N*	*T*
1	2	224.97	243.00	39	2.99†
3	4	63.14	68.38	39	3.01†
5	6	40.00	43.12	39	1.96 N.S.
7	8	42.74	45.79	39	1.75 N.S.
9	10	7.37	7.37	34	0.04 N.S.
11	12	92.50	94.29	34	1.81 N.S.
13	14	78.29	82.26	34	2.12‡
15	16	47.05	45.97	34	0.87 N.S.

N=Number of paired measures. T=Student's "T" test.

N.S.=Means non-significant difference between means.

*Variable factors before (first) and after (second) six weeks of training.

†=Means are significantly different at the .01 probability level.

‡=Means are significantly different at the .05 probability level.

1 vs 2—Forced expiration volume liters.

3 vs 4—Forced expiration volume liters: Per cent of predicted normal.

5 vs 6—Maximal voluntary ventilation (L/Min).

7 vs 8—Maximal voluntary ventilation (L/Min): Per cent of predicted normal.

9 vs 10—Blood pH, units.

11 vs 12—Arterial O_2 saturation per cent.

13 vs 14—Arterial O_2 tension, pO_2, mm, Hg.

15 vs 16—Arterial CO_2 tension, pCO_2, mm, Hg.

Information in this table prepared by the Western Research Support Center, Veterans Administration, Sepulveda, California.

expansion changes at navel level indicate improvement in diaphragmatic excursion. No changes were noted in measurement at the nipple or rib angle.

Table 6 shows the functional activities and breathing exercises measured initially and after training.

Occupational Therapy Activities. Four patients refused to enroll in programed activities, but participated in recreational activities (billiards, model assembly). Motivation was high to adequate in 32 patients, poor in four. Ninety per cent of the patients had good to excellent attendance. The activity tolerance, as measured by the finished task, showed an increase. Ninety per cent of the patients progressed to 60 minutes of activity in sitting or standing positions. The patients became less anxious and restless as indicated in their ability to relax, as follows:

	Poor	*Fair*	*Good*
At start of program	20	14	6
Six weeks later	3	21	16

Of the 40 patients studied, 11 used the intermittent positive pressure breathing aid before entering the hospital, 24 during the stay in hospital and four after the training period. There was less reliance on IPPB apparatus after training.

None of the eight patients who had previous history and findings of right heart failure had cardiac difficulty during the training, in spite of a doubling of activity.

A more efficient respiratory pattern was developed during exercise, and this change could reduce the energy cost of breathing.[10]

Certain weight changes occurred during training. On the regular hospital diet, 15 underweight patients gained an average of 3.6 pounds, 15 normal weight patients gained an average of 4.5 pounds and 10 overweight patients lost 5.6 pounds on a regular hospital diet.

Thirty patients showed grade changes in dyspnea and 20 had changes in ventilatory function as shown on Table 2.

After the six-week program, the patients were interviewed. The subjective improvement reported by the patients was one of the most important factors in the motivation of the patients. This interview indicated that the patients felt better and enjoyed the exercise program and the increased physical activity. They could breathe easier, they worried less about their conditions, they felt their food tasted better and their outlook became more optimistic.

Preliminary observations indicated that 80 per cent of the patients maintained or even improved their functional activity levels when observed three, six, nine and twelve months after the six-week training period.

Discussion

Barry[5] reported similar improvement in work capacity in post-coronary patients who were trained in a way similar to that described in the present report. Direct supervision helped maintain the patients' motivation[2,5,6] and prevented overindulgence of exercises.

Physical fitness may be defined as the ability to maintain certain cardiorespiratory functions as

TABLE 6.—*Variables in Function Before and After Exercise Training*

Variables First	*Variables* Second	*Mean of First Variable*	*Mean of Second Variable*	*N*	*T*
1	2	224.43	425.21	37	3.05†
3	4	1.83	2.86	37	5.29†
5	6	59.56	67.02	37	1.60 N.S.
7	8	161.64	233.82	34	4.63†
9	10	77.91	148.22	36	7.51†
11	12	100.38	164.19	36	6.63†
13	14	62.51	72.81	37	4.56†
15	16	70.18	78.00	37	3.68†
17	18	2.59	1.40	37	−4.68†
19	20	21.10	38.59	37	7.63†
21	22	0.53	1.54	34	4.55†
23	24	2.58	2.33	39	−2.51*

First initial measurements. Second after six weeks of training.
N=Number of paired measures. T=Student's "T" test.
N.S.=Means non-significant difference between means.
*=Means are significantly different at the .05 probability level.
†=Means are significantly different at the .01 probability level.
1 vs 2—Time in seconds—walking on level.
3 vs 4—Number of standard flights—stair climbing ability (1 flight=20—7 inch risers and 1 landing mid-flight).
5 vs 6—Number in seconds—stair climbing.
7 vs 8—Time in seconds Exerow can be tolerated.
9 vs 10—Treadmill, 15 per cent grade-peds walked.
11 vs 12—Treadmill time in seconds.
13 vs 14—Left hand grip (pounds).
15 vs 16—Right hand grip (pounds).
17 vs 18—Number of blows to transfer 1 liter of water.
19 vs 20—Longest single blow in seconds.
21 vs 22—Expansion changes measured at navel line (inches).
23 vs 24—Emphysema grade changes.
Information in this table prepared by the Western Research Support Center, Veterans Administration, Sepulveda, California.

closely as possible to the resting state during exertion and to recover promptly from any disturbed function[5] induced by exercise. Walking reflects physical fitness to some degree when the maximum speed at which the patient walks for a specific period and the length of time a patient walks at a particular speed are considered.[7] Physical fitness of the COPE patients, as measured by functional activities, was improved and efficiency in performing physical work was increased by carrying out a combined exercise program. In addition, patients showed increased capacity for work as demonstrated by their ability to walk farther and climb more steps with increased speed, to tolerate rowing machine and occupational therapy activities and the like. Speeds that could not be tolerated before training were sustained after training. All these observations, including the objective measurements and the subjective improvement reported by the patients, indicate that a prescribed exercise program is beneficial and a worthwhile supplement to medical therapy. Graded exercise has a definite place in the routine care of chronic obstructive pulmonary emphysema.

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